

Figure 1 - Error Recovery Architecture

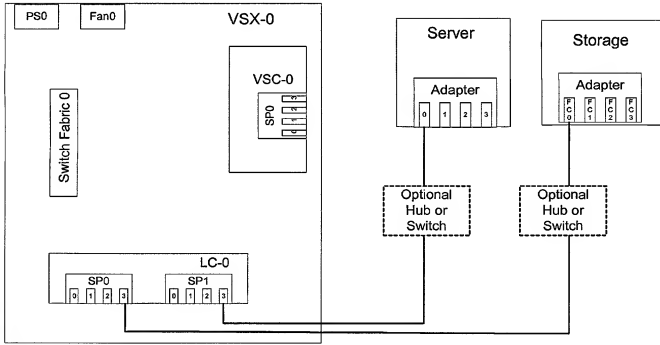


Figure 2 - Non-Fault Tolerant Configuration

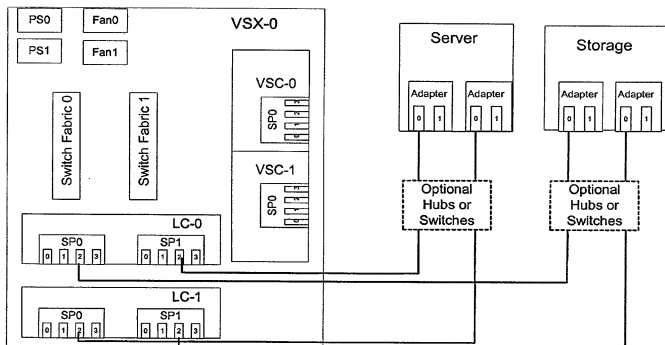


Figure 3 - Fault Tolerant Configuration

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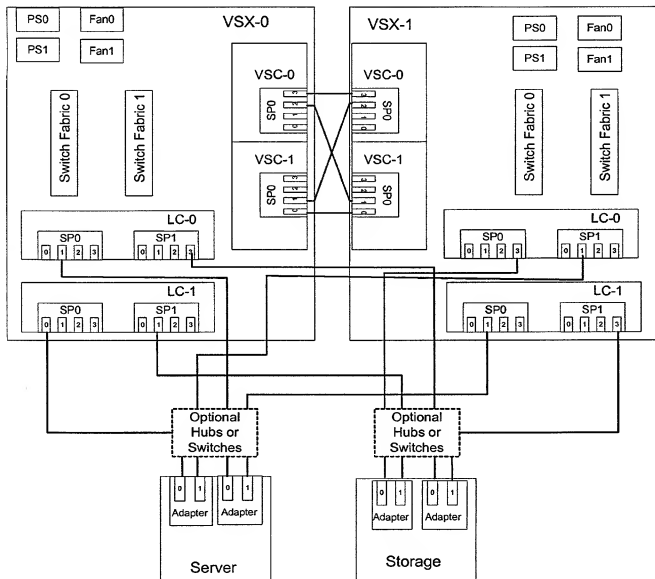


Figure 4 – High Availability Configuration

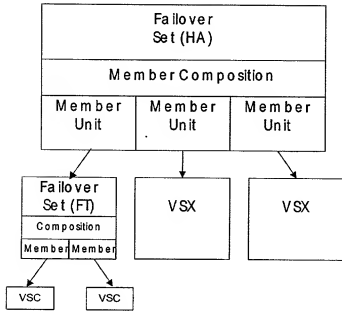


Figure 5 Components of a Failover Set

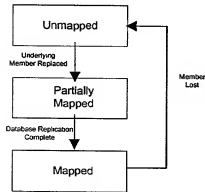


Figure 6: Member Unit State Diagram

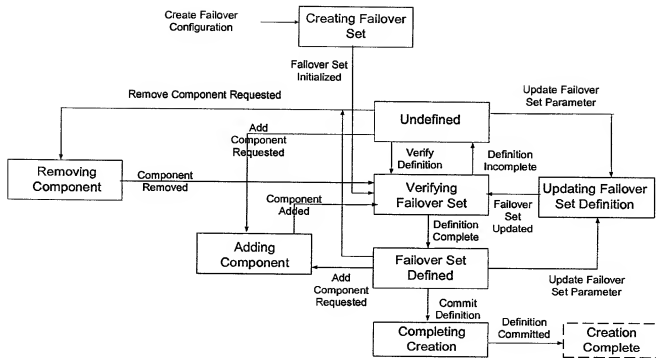


Figure 7 - Creating a Failover Set

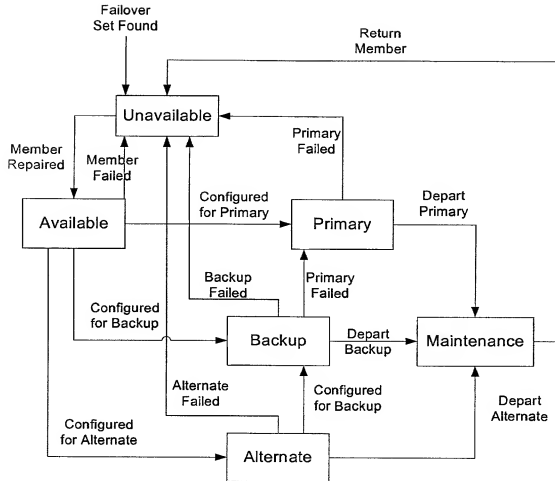


Figure 8 - Member State Diagram

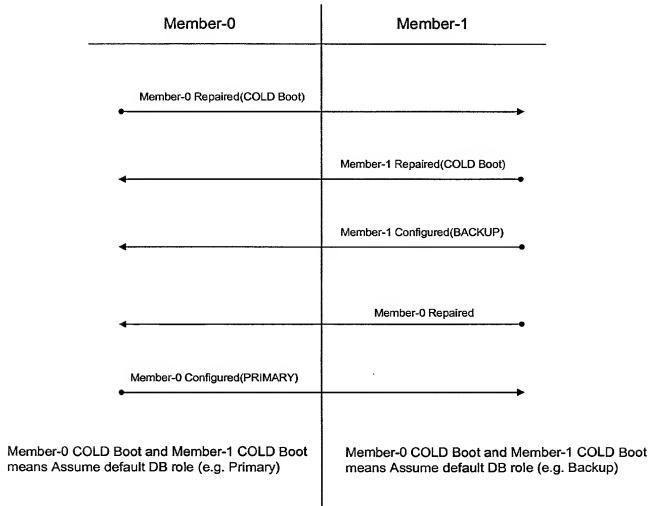


Figure 9 - Member Arbitration for COLD Boot

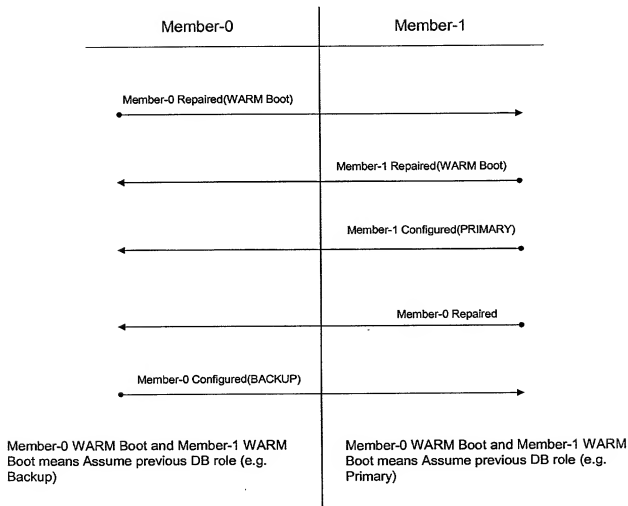


Figure 10 - Member Arbitration for WARM Boot

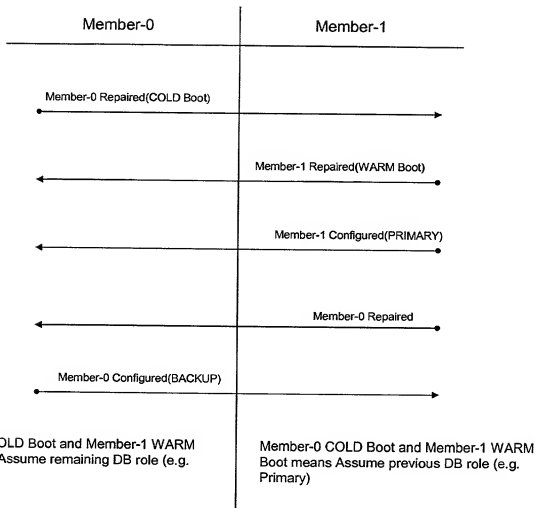


Figure 11 - Member Arbitration for Mixed Boot

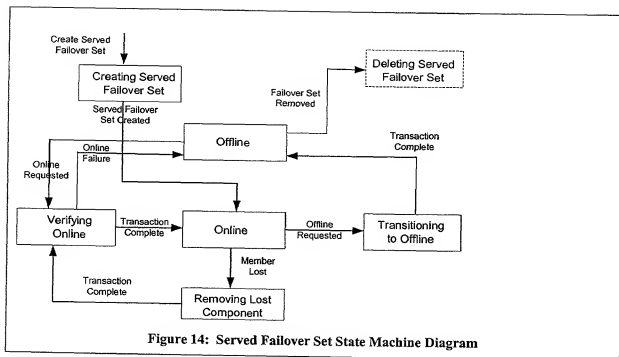
Old State	Event	Mj Repaired	Mi Configured	Mj Configured	Mi Failed	Mj Failed
1. {Mi,Mj} Unavail, {} Avail, {} Primary, {} Backup*	Mj Repaired New St: 3 Action: A	New St: 2 Action: B			New St: 1 Action: S	New St: 1 Action: T
2. {Mi} Unavail, {Mj} Avail, {} Primary, {} Backup	New St: 4 Action: C			New St: 8 Action: D	New St: 2 Action: S	
3. {Mj} Unavail, {Mi} Avail, {} Primary, {} Backup		New St: 4 Action: E	New St: 9 Action: F			New St: 3 Action: T
4. {} Unavail, {Mi, Mj} Avail, {} Primary, {} Backup			New State: 7 Action: G	New St: 6 Action: H		
5a. {} Unavail, {} Avail, {Mi} Pri, {Mj} Backup					New St: 8 Action: I	New St: 9 Action: J
5b. {} Unavail, {} Avail, {Mj} Pri, {Mi} Backup					New St: 8 Action: I	New St: 9 Action: J
6. {} Unavail, {Mi} Avail, {Mj} Pri, {} Backup	New St: 6 Action: K		New St: 5a, 5b Action: L			New St: 3 Action: M
7. {} Unavail, {Mj} Avail, {Mi} Pri, {} Backup		New St: 7 Action: N		New St: 5a, 5b Action: O	New St: 2 Action: P	
8. {Mi} Unavail, {} Avail, {Mj} Pri, {} Backup	New St: 6 Action: C					New St: 1 Action: Q
9. {Mj} Unavail, {} Avail, {Mi} Pri, {} Backup		New St: 7 Action: E			New St: 1 Action: R	
* Initial State						

Figure 12 - 2 Member State Table

Action Routines	Description
I	1. Send "Mi repaired" to Mj, if Mj is not failed. 2. Set timer to send "Mi repaired" to Mi
2	1. Send "Mj repaired" to Mi, if Mi is not failed. 2. Set timer to send "Mj repaired" to Mj
A	1. If Mi and configured send "Mi configured" to Mj. 2. Set timer to send "Mi configured" to Mi. 3.
B	1. If Mj and configured send "Mj configured" to Mi. 2. Set timer to send "Mj configured" to Mj. 3.
C	1. If Mj, echo event back to Mi. 2. If Mi and configured send "Mi configured" to Mj. 3. Set timer to
D	1. If Mj become Primary. 2. Otherwise, nop.
E	1. If Mi, echo event back to Mj. 2. If Mj and configured send "Mj configured" to Mi. 3. Set timer to
F	1. If Mi become Primary. 2. Otherwise, nop.
G	1. If Mi become Primary. 2. Otherwise, echo event back to Mi.
H	1. If Mj become Primary. 2. Otherwise, echo event back to Mj.
I	1. If Mj become Primary. 2. If Mi become Backup.
J	1. If Mi become Primary. 2. If Mj become Backup.
K	1. If Mj echo event back to Mi. 2. Otherwise, nop
L	1. If Mj determine Member Role. 2. Send "Mi configured" to Mi when done. 3. If Mi determine
M	1. If Mj perform Fail-Stop processing. 2. Send "Mj Failed" to Mi. 3. Otherwise become Primary after
N	1. If Mi echo event back to Mj. 2. Otherwise, nop
O	1. If Mi determine Member role. 2. Send "Mj configured" to Mj when done. 3. If Mj determine
P	1. If Mi perform Fail-Stop processing. 2. Send "Mi Failed" to Mj. 3. Otherwise become Primary after
Q	1. If Mj perform Fail-Stop processing for Mj. 2. Otherwise nop.
R	1. If Mi perform Fail-Stop processing for Mi. 2. Otherwise nop.
S	1. Perform Fail-Stop processing for Mi
T	1. Perform Fail-Stop processing for Mj

Figure 13 –Action Routines for a 2 Node Configuration

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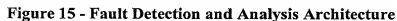
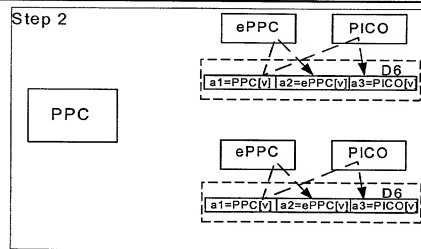
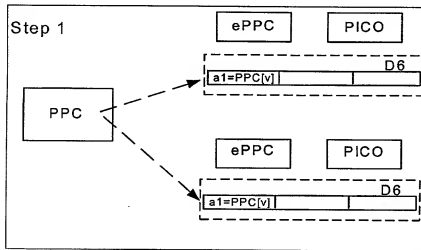


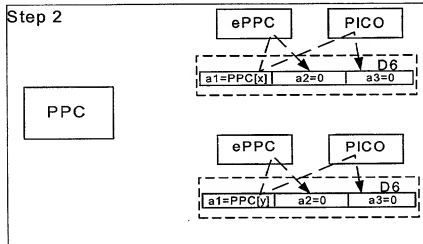
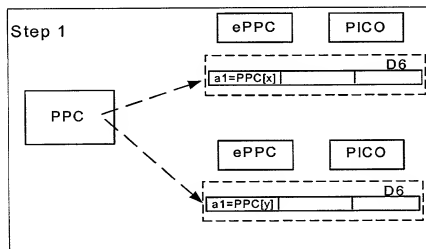
Figure 15 - Fault Detection and Analysis Architecture



Step 3

$\text{majority}(a1, a2, a3) = \text{majority}(v, v, v) = v$, No faults

Figure 16 - No faults



Step 3

$\text{majority}(a1, a2, a3) = \text{majority}(x, 0, 0) = 0$, transmitter fault

Figure 17 - Transmitter fault (sends a bad value)

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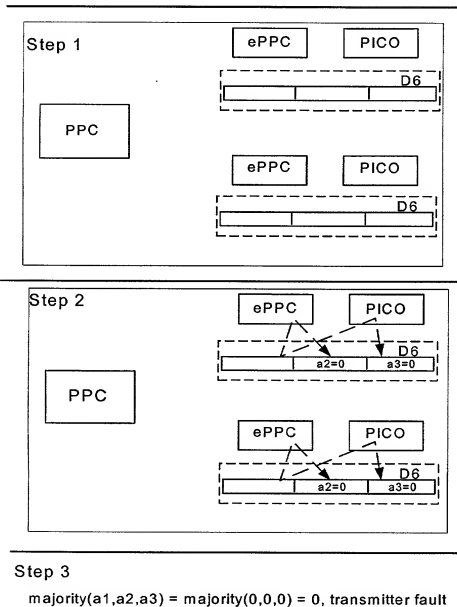
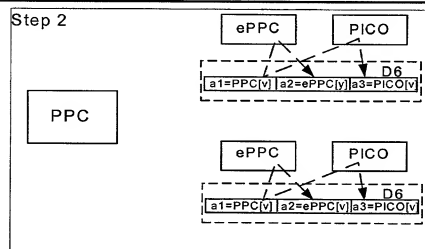
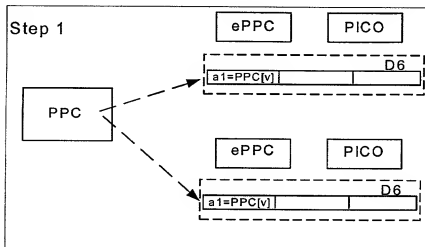


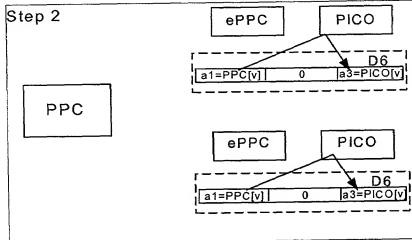
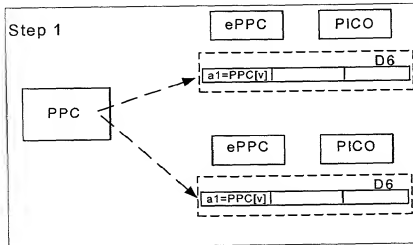
Figure 18 - Transmitter fault (doesn't send a value)



Step 3

$\text{majority}(a1,a2,a3) = \text{majority}(v,v,v) = v$, Receiver fault

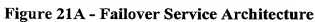
Figure 19 – Receiver fault (relays wrong value)



Step 3

$\text{majority}(a1, a2, a3) = \text{majority}(v, 0, v) = v$, Receiver fault

Figure 20 - Receiver fault (doesn't relay a value)



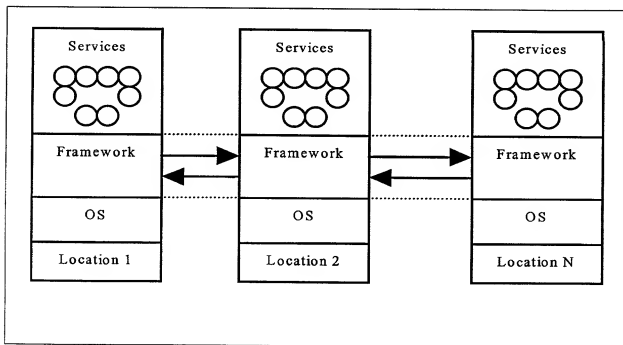


Figure 21B

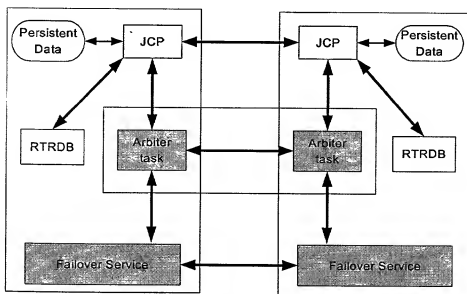


Figure 22 - An Arbiter for the Database

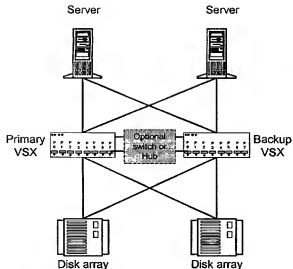


Figure 23 -Shared Link

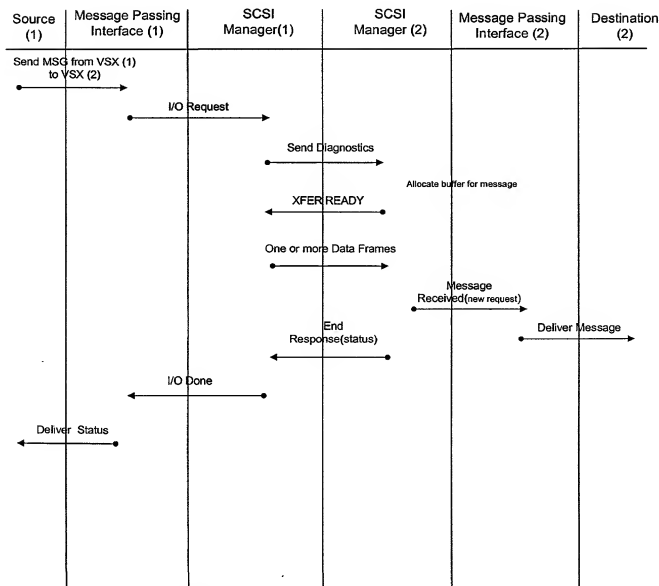


Figure 24 - VSX to VSX Message Passing

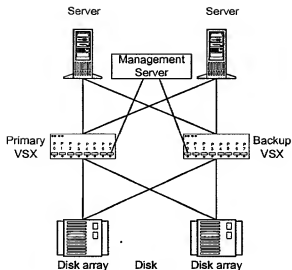


Figure 25 - Management Link

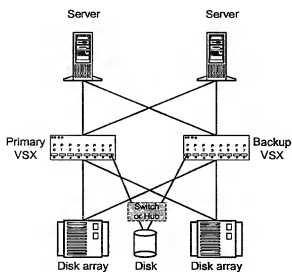


Figure 26 - Shared Disk

10076906.027302

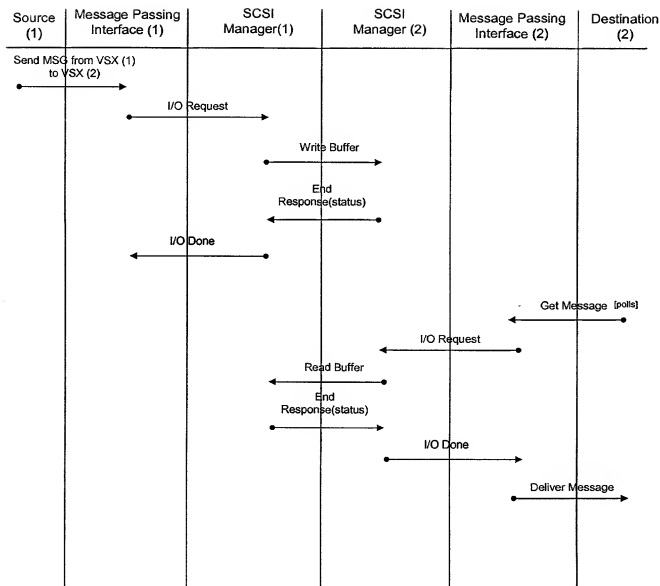


Figure 27 – VSX to VSX communication Using Shared Disk

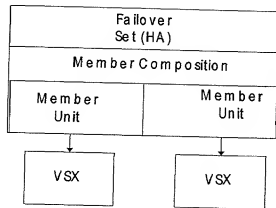
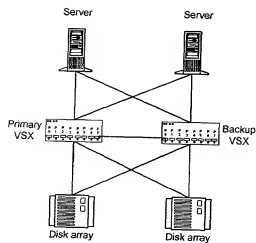


Figure 28-2 Node HA Configuration

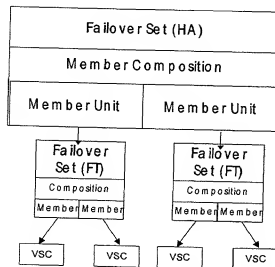
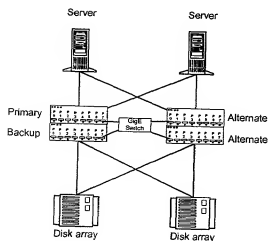


Figure 29 - Hierarchical HA Configuration

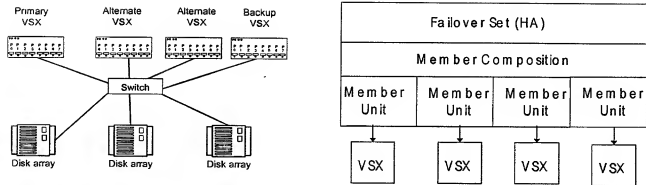


Figure 30 - N + 1 Nodes

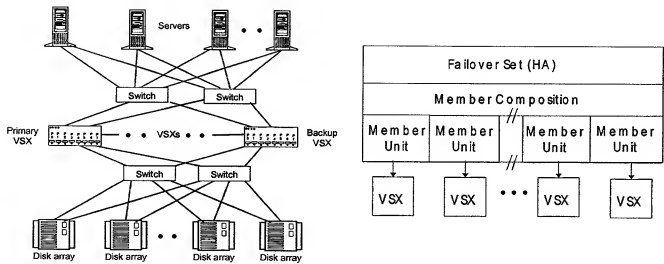
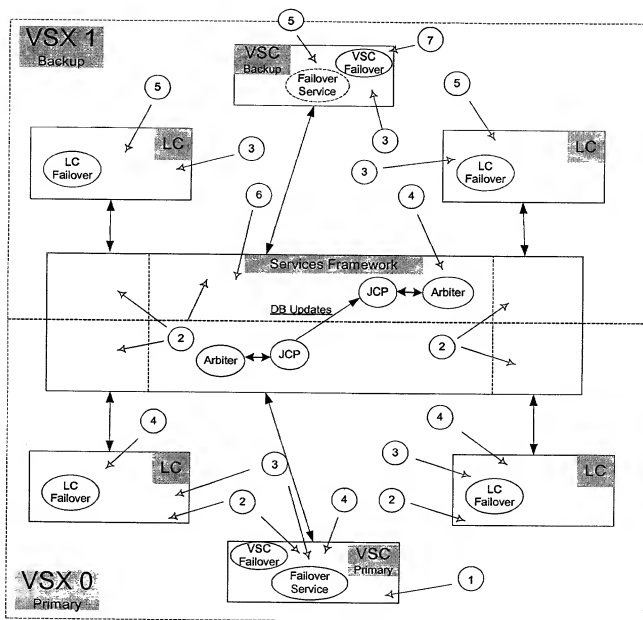
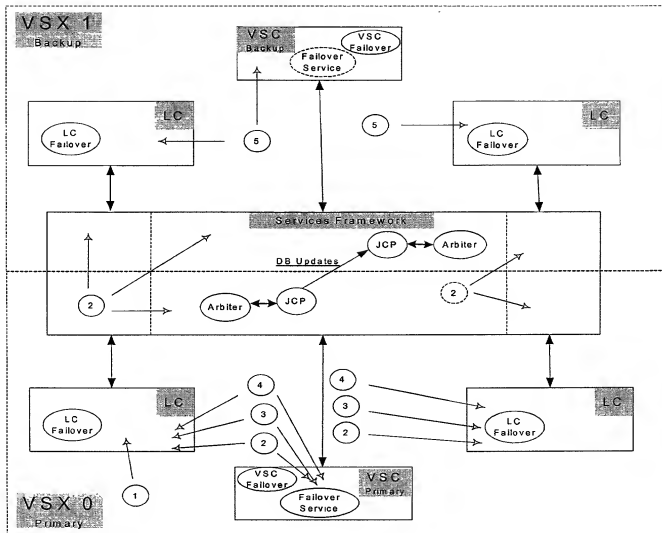


Figure 31 - N - Nodes



1. VSC Crashes (Host Processor)
2. Rest of system detects VSC crash
3. Error Analysis determines Member fails, which translates into a "Primary Lost" event
4. Activate JCP in Master mode and enable the virtual services, Stop Ports on failed Primary
5. Reset affected devices, Cleanup reservations and locks, Set Unit Attention
6. Restart management requests
7. Restart RCON and FORMAT

Figure 32 - VSX Failover, Primary Fails



1. LC Crashes (Host Processor)
2. Rest of system detects LC crash
3. Error Analysis determines IO Path fails for all devices (server and storage) on LC
4. Upstream hLUNs report CHECK CONDITION for all devices connected to ports on failed LC. RCON and FORMAT aborted, if necessary.
5. Restart RCON and FORMAT, if necessary

Figure 33 - IO Path Failover - LC Fails

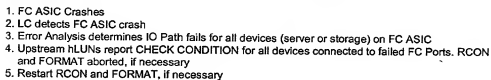


Figure 34 - IO Path Failover - FC Port Fails

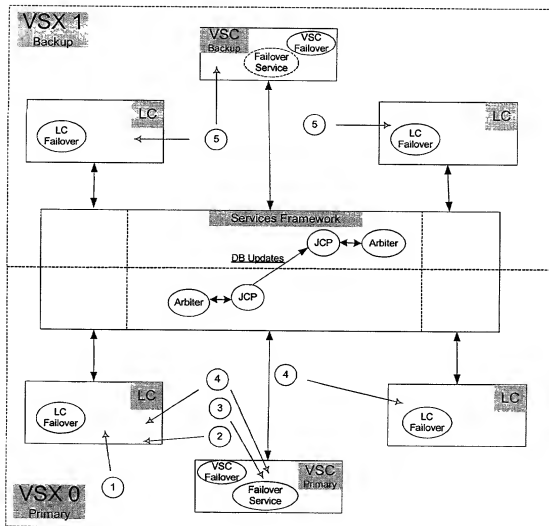


Figure 35 - IO Path Failover - Link Down

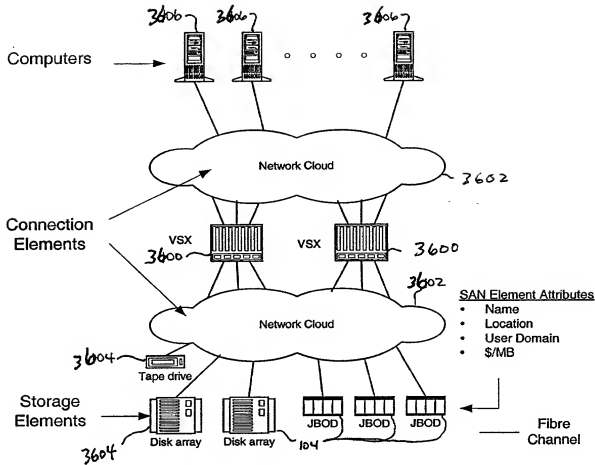


Fig. 36

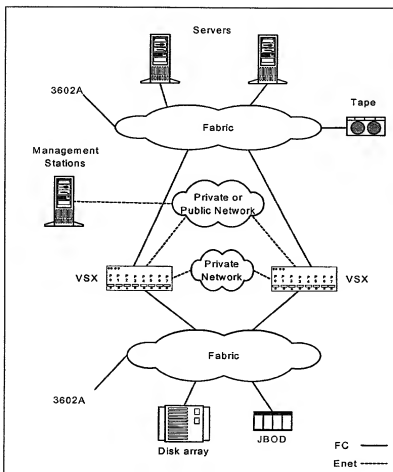


Figure 36 A Physical Setup for VSX-HA – Variation 1

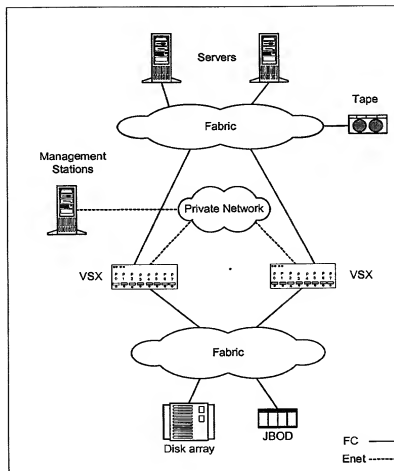


Figure 36 B Physical Setup for VSX-HA – Variation 2

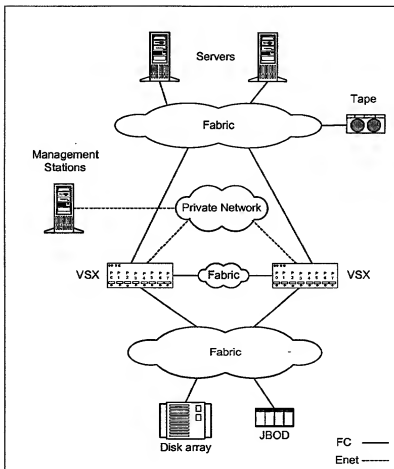


Figure 36 C Physical Setup for VSX-HA - Variation 3

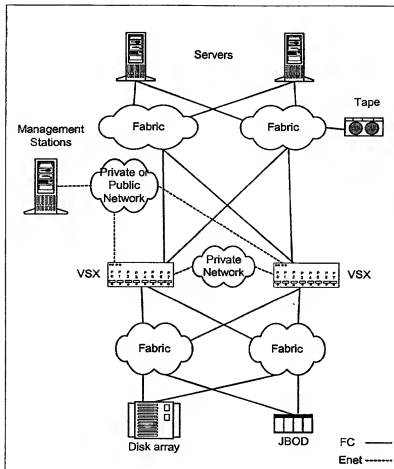


Figure 36 D Physical Setup for VSX-HA – Variation 4

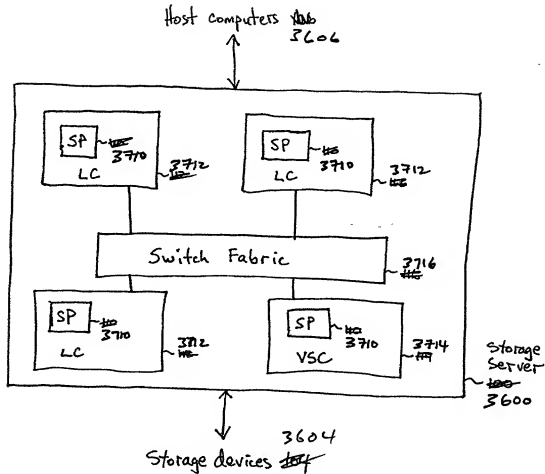


Fig. 37